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Image processing based method to assess fish quality and freshness

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ABSTRACT

The quality of a fish may be affected primarily by handling, processing and storage procedures from the catch to consumers. Retention time and storage temperature of post-harvested fish are key factors for sustaining the final quality of this product. This paper proposes an image processing method which is completely automatic, efficient and non-destructive for segmentation of tissues and prediction of freshness of the fish sample. The gill tissues of the fish sample are automatically segmented using a clustering based method and its features are strategically extracted in the wavelet transformation domain using Haar filter. First, second and third level decomposition in the wavelet domain is performed and the coefficients obtained at each level have been analyzed to predict the freshness of the fish sample. The experimental results indicate a monotonic variation pattern of the coefficients at the third level of decomposition and these coefficients gives an indication of the quality of the fish. This discriminatory variation in the image features with the duration of retention time provides a strategic framework for assessment of fish freshness.

1. Introduction

Aquaculture is one of the fastest growing food-producing segments and is maintaining its growth potential along with field crops and livestock productivity (Troell et al., 2014). In recent times, capture fisheries showed a sharp fall in the productivity domain due to overexploitation, atmospheric catastrophe and pollution impacts, whereas aquaculture heralded a new dawn of enhanced yield and sustained income generation. But increased fish production is not synonymous with healthy and quality fish protein for human consumption. Being a perishable entity, fish freshness and quality are important indicators of its commercial success as commodity. Moreover, fish harvested at local ponds and industrial farms are not always consumed by adjoining markets and are carried to fish loving 'hot spots' to sustain its marketability and profitability. Ice is the an important preservative media for fish (Rahman et al., 2012) and maintaining at ice embedded cold chain is the most common preservative technique of post-harvested fish to inhibit its decaying process and acts as a prime insulator during transportation. But its preservation efficacy also depends on ice quantity, tenure of ice application, origin of fish stock and its types, pathogen and toxicity loads and above all, climatic conditions.

Multiple reports of compromised quality are surfaced from the post-harvested fishes surveyed at markets and distribution channels (Hossain et al., 2013). The quality attributes include a series of parameters related to safety, nutritional quality, availability, freshness and edibility, which may be affected mainly by handling, processing and storage procedures from the catch to the consumers. Practically, physical, chemical, biochemical and microbiological changes occurring post-mortem in fishes, result in a progressive lost of food characteristics in terms of taste and a general concept of quality (Olafsdottir et al., 1997). Selling of pathogen infected, formalin (Goon et al., 2014) and pesticides loaded fish are not only potential health hazards to human, but also can influence fish degradation pattern and deteriorate its quality.

Fish freshness is the most required property from the consumers because of its strong relationship to the taste and health. A number of sensorial inspection procedures have been introduced to point the state of freshness. These procedures involve the use of sight (to evaluate the skin appearance and the color and the global aspect of eyes), tactile (to test the flesh firmness and elasticity) and olfaction (to smell the gill odor) etc. But most of the times, these quality linked factors remained unnoticed, as the detection methods are invasive and costly. Government sponsored quality testing laboratory generally maintains such low cost services for export clearances and can only accept low sample size. Moreover,

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innovative tools like biosensor and nanotechnology based fish quality testing kits are available but not popular due to their inherent problems and common people and fish farmers do not have any access to such tools. Sensory evaluation dependant 'quality index method (QIM)' is also complex as it dealt with multiple characters of different fish tissues (Macagnano et al., 2005). Hence, a simple, fast and effective tool is required which can function as model platform and reference point to compare and validate fish quality issues.

Gill is the red colored respiratory tissue of fish and its colour and odour pattern is used as apparent freshness indicator (Macagnano et al., 2005). But this 'vision' based colorimetric technique is very basic, indiscernible and can be misinterpreted. Moreover, unfolding the scientific basis and validation of 'gill color' may be required, before applying it as quality indicator at post-harvested fishes. Rohu (*Labeo rohita*) is the most preferred, commercial major carp in the Indian subcontinent (Das et al., 2005). Hence, selecting rohu gill for evaluating fish quality and freshness pattern can be a widely acceptable candidate mimicking other popular fish variety.

Image analysis is a non-destructive, non-hazardous common tool for evaluating data based on photography and analysis of its color variations through imaging software can be an important method to validate the quality of fish (Menesatti et al., 2010). Some work has already been reported in food processing sectors using the image processing. Feng Wang et al. (Wang et al., 2013) proposed a regression based technique on the eye from the fish sample to detect its freshness. Fairuz Muhamad et al. (Muhamad, Hashim, Jarmin, Ahmad) revealed a fuzzy logic based method for classification of fish freshness. Shiv Ram Dubey et al. (Dubey et al., 2013) described a colour based segmentation technique to detect the infected region in a fruit image. Soumya et al. (Band and Sheelarani, 2009) used soft computing techniques such as c-means clustering and fuzzy logic for segmentation of color images. Shiv Ram Dubey et al. (Dubey and Jalal, 2014) has applied sum and difference histogram texture based features for detection of defects in fruits.

The main objective of the paper is the assessment of fish quality and freshness. This is achieved by using an image processing technique which is a non destructive and non-hazardous method of assessment. A chemical based assessment leads to destruction of the sample under test and the sample cannot be used further. However, with image processing, only an image of the fish is taken and using some segmentation techniques, the gills tissue are segmented and analyzed. Some discriminatory features are obtained during the analysis of the tissues. This can help in development of a viable tool which can work in real time for fish quality assessment.

The main contribution of the paper is an efficient image processing based method for assessment of the quality and freshness of the fish. This is achieved by analyzing the wavelet domain features of the segmented tissue of the gills from the fish image. A comprehensive statistical and image processing techniques has been presented to explore these image feature variations in segmented gill pattern to develop viable tool for predicting fish quality and freshness.

Another contribution of the paper lies in the use of a clustering based image processing technique for automatic segmentation of the gills from the fish image. The proposed segmentation method for segmentation of gills is completely automatic, less complex and computationally efficient.

The highlight of this work is the establishment of a strategic relationship between the image coefficients, extracted during wavelet domain analysis, and the quality and freshness of the fish. This relationship can act as indicative parameters for a viable image processing based non-destructive diagnostic tool for quality check and control.

The rest of the paper is organized as follows. Section 2 presents the materials and methods used in the work. This section discusses the process involved for capturing images of the fish samples for the experimental study and the imaging tool for feature extraction from these images. Section 3 presents the experimental results and discussion on these results. The conclusions from the work are reported in Section 4 of the paper.

2. Materials and methods

2.1. Collection of fish samples

The live Rohu(*L. rohita*) were sampled from fish ponds National Institute of Abiotic Stress Management (NIASM), Baramati, Pune, Maharashtra (18°09′30.62′N and 74°30′03.08′E; Mean sea level − 570 m) and kept in three hundred litres aquariums for 24 h. The average weight and average length of fishes were 90.40 ± 1.20 g and 21.60 ± 0.50 cm respectively. The pond water were free from any pathogenic infestation and toxic residues as were measured through routine microbiology and toxicity detection protocol, prior to the initiation of experiments.

2.2. Experimental design and photography

Fishes from the aquariums were taken out and placed into chilled water for sudden death to avoid rigor mortise. The fishes thereafter were preserved for imagining study in thermocol boxes ($28 \times 18 \times 12$ cm^3) with a fish to ice ratio of 1:2. Images of gill were taken using NIKON D90 digital camera on first day and at every two days interval till thirteen day. The captured images are of the size 601×361 pixels.

2.3. Morphometric analysis of the fish

Different body parts of the fish can be used for freshness determination. The freshness identification can be done using different parameters which can be classified on the basis of general aspect, appearance, smell, pigmentation, rigidity, odour, coloration, etc. of the fish samples under study (Huss, 1995). Out of the above mentioned parameters, the appearance of the gills has been used as a parameter under consideration for assessing the freshness of the fish. This is so because for an image processing based diagnosis, parameters that show perceptible changes visually should be considered for analysis. In the proposed work, the image coefficients show a discriminatory pattern with respect to the fish freshness and are used in providing a framework for freshness classification.

2.4. Proposed method

The proposed image processing based method of freshness identification in fish samples involves feature extraction from segmented red channel image of gills followed by feature analysis of the coefficients of wavelet transform. To extract the accurate and discriminatory features from the image, the portion of the image which contains maximum information is required to be segmented from the whole image. As the perceptible and discriminatory changes of the gills seem to be a good choice for freshness identification, they are the Region of Interest (ROI) in this case.

Choice of Wavelet domain coefficients for Image Analysis: The texture features of image in spatial domain may not be effective enough for analysis of the segmented gill tissues for image classification as these are limited to pixel intensity values and there is no information about hidden frequency content. Wavelet transform domain coefficients have better discriminatory features for establishing the freshness levels of the fish as these coefficients captures both the spatial and frequency information of an image. In this case the image is represented in terms of the frequency of content of local regions over a range of scales and this representation seems to